NASA
Lewis Research Center
Technical Memorandum 100270

Technical Writing Standards for Contractor Reports

Technical Information Services Division
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Foreword

The National Aeronautics and Space Act of 1958, Section 203, paragraph (a)(3), states that one of the functions of the National Aeronautics and Space Administration is to "provide for the widest practicable and appropriate dissemination of information concerning its activities and the results thereof." One way this function is accomplished is through technical reports prepared by contractors on work performed under NASA contracts. Lewis Research Center contractors publish approximately 300 NASA Contractor Reports each year.

The quality and format of these reports, particularly as submitted to the NASA Lewis Project Manager, have varied widely, with some attendant loss in utility of the reported information. The standards presented in this guide are intended for use in all contractor and grantee reports in the formal NASA CR (Contractor Report) series to improve the quality of presentation and to standardize the format for these reports so that the information is more readily accessible.

All available NASA publication standards were considered for incorporation into this manual and the portions applicable to CR's were either adopted or modified for inclusion. Both mandatory and optional standards are included.

The guide, which is an update of the NASA Lewis Handbook 2230.1, was coordinated by Joyce C. Cieszewski with the assistance of Marilyn V. Weaver and Margaret C. Appleby. Copies of the guide may be obtained through NASA Lewis Project Managers or from the NASA Lewis Research Center, Editorial Branch (MS 60–1), 21000 Brookpark Road, Cleveland, Ohio 44135, telephone (216) 433–5792. Questions regarding the content of this publication should be directed to Sylvia C. Taylor, Chief, Editorial Branch.

George Mandel
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Introduction

A basic responsibility of both NASA and its contractors is to report the results of their work to the scientific community. The value of research and technology information so reported is greatly enhanced if it is presented in an accessible form and distributed quickly to those who may make use of it. With these objectives, this guide provides both mandatory and optional standards for use in preparing formal contractor technical reports in the NASA CR (Contractor Report) series.

Nothing contained in this manual shall be construed as authority to change or amend the Reports of Work clause of the contract or any direction that may have been given by the NASA Contracting Officer and/or the NASA Project Manager. The contractor shall resolve any questions regarding interpretation or applicability of these instructions with the NASA Contracting Officer and/or the NASA Project Manager. (NASA Project Manager denotes the individual who has been officially assigned to manage technically the contract work for the NASA Lewis Research Center.)

In carrying out the part of its mission that involves information dissemination, NASA is governed both by Federal interagency regulations and by its own internal standards and practices. The interagency regulations listed in the Government Printing and Binding Regulations are monitored by the Joint Committee on Printing, whose primary concern is to ensure Governmentwide economy in printing and binding. NASA is also governed by the publication policies of the United States Government Printing Office (GPO). The U.S. GPO Style Manual is a Governmentwide guide intended to improve the clarity and quality of Government publications, including contractor reports. The GPO Style Manual and the NASA Thesaurus are guides for spelling.

This CR guide does not treat the subject of English grammar and usage. Several books in the Bibliography are sources for that information. Nor does it prescribe the specific detail that should appear in a report. The specific detail is considered to be the province of the authors and of the NASA Project Manager. Rather, one intent is to provide a standard format to which the specific technical information can be related. The format is common to much of the scientific community and to all of NASA specifically. A second intent is to provide other specific standards of style and format that will improve the quality of the publication. Above all, this manual is intended to improve communication between the authors of the contractor report and the reader.

The principal part of this manual discusses the types of CR's, authorship, reporting requirements, distribution, numbering system, announcement, and availability of formal contractor reports; treats the report format, including general discussions of the purpose and general content of each section of the CR; and describes those miscellaneous style and quality requirements that are generally applicable to all formal NASA publications.

Specific requirements for CR's prepared on contractor projects for the U.S. Department of Energy (DOE) are given in appendix A.

Contractor Technical Reports

Report Types

Reports that are contractually required for submittal to the NASA Lewis Research Center are divided into two categories, informal and formal CR's.

Informal reports.—A mixture of technical, schedule, and financial information comprises informal reports written to facilitate the management and periodic review of the work under the contract. These reports are of primary and temporary interest to the parties to the contract. The distribution of these reports is normally less than 20 copies. The scope, format, content, and distribution of informal reports are established by the contract. Any technical information from them would necessarily be extracted and rewritten before being published as a journal article or published separately as a formal NASA report. The standards for each type of document would apply to this rewritten material. Therefore, informal periodic reports will not be discussed further in this manual; they are not assigned NASA CR numbers by Lewis Research Center and are not distributed except as expressly provided in the contract.

Formal reports.—The formal report category includes all contractor reports that contain only technical information. Contractor reports referred to as "Interim," "Quarterly," "Semiannual," "Annual," "Topical," and "Final," are developed by the contractor and submitted to NASA for review and approval before release. These reports are published in the formal NASA CR series discussed in this guide. The formal CR contains only technical information that is of probable

interest to the appropriate scientific community. The nature and content of a CR determines whether it is in the low- or high-numbered subseries. A summary of some information about low- and high-numbered CR's and DOE (high-numbered) CR's is given in table I.

NASA CR's in the low-numbered subseries (i.e., with serial numbers below 50 000) are written and edited by the contractor and approved by the NASA Project Manager. The content of these CR's is determined to be of major interest to the technical community: they are similar in content and quality to that of a NASA Technical Paper (TP). They are both printed and distributed by NASA. Distribution of low-numbered CR's is made to an approved international and domestic mailing list that varies according to the category of information contained in the report. Typically, about 450 to 600 copies are published. These CR's are made available for sale by the National Technical Information Service (NTIS), Springfield, Virginia 22161.

NASA CR's in the high-numbered series (i.e., with serial numbers above 100 000) generally contain technical information of limited interest. These reports are written and edited by the contractor, approved by NASA, and then printed and distributed by the contractor to a mailing list approved or prepared by the Lewis Project Manager. The Lewis Project Manager provides the contractor with serial numbers for these reports. Typically, this report distribution involves 50 to 150 copies. Further reference to CR's in this manual applies to the formal CR report series only.

Authorship

The authorship of NASA publications is generally reserved for persons who participated in the performance of the work from which the scientific and technical information resulted. NASA employees may not be coauthors of CR's. When NASA employees contribute to, rather than merely monitor, contract or grant work, such work should be published in another NASA series (Technical Papers, Reference Publications, or Technical Memorandums).

Reporting Requirements

The type of CR required and the procedure for submittal are established in the schedule in the specific contract. This schedule also designates the reporting requirements and the number of copies to be submitted to the Lewis Research Center for review.

The contractor is responsible both for the preparation of the CR in conformance with this manual and for the technical accuracy of the contents. The NASA Project Manager conducts the final review of the report and indicates the changes required to make the report acceptable by transmittal of a letter or annotated report, or both, to the contractor. When the report is acceptable, both the NASA Project Manager and the Contracting Officer approve the report for NASA.

If NASA determines that the report merits wide distribution, the report becomes a low-numbered CR. The NASA Project Manager will act as liaison with the contractor to ensure that the requirements of the Lewis Technical Information Services Divison are met so that NASA can publish the report.

Report Distribution

Low-numbered CR's are printed and distributed by the NASA Langley Research Center's printing facility according to a standard list for the NASA Subject Category selected by the NASA Project Manager. The list of these categories is given in appendix B. The NASA Project Manager may augment this distribution by providing the NASA Lewis Technical Information Services Division with mailing labels for those individuals known to have an interest in the report.

In rare instances when it is necessary to disclose the information contained in a proposed low-numbered CR to those having an urgent need, the NASA Project Manager may distribute a small number of preliminary copies with NASA Headquarters approval. These copies carry the statement "ADVANCE INFORMATION" on the cover. The advance information copies will *not* have NASA CR numbers.

High-numbered CR's are printed and distributed to a NASA Headquarters approved list of recipients. The specific requirements for CR distribution are stated in the contract. The NASA Project Manager or Contracting Officer provides this approved distribution list, which is transmitted to the contractor through the Contracting Officer. The minimum distribution for NASA high-numbered CR's and DOE CR's is given in table II.

The copies of high-numbered CR's sent to the NASA Scientific and Technical Information Facility (STIF) are used to process the report into the NASA computerized data bank including announcement in STAR (Scientific and Technical Aerospace Reports). In addition, STIF forwards copies to NTIS for subsequent sale to requestors.

The NASA Project Manager may add to the minimum distribution. The maximum total number of pages printed, however, may not exceed 25 000 (12 500 sheets of paper printed on two sides). For example, a total of no more than 62 copies of a 400-page report would be permitted.

Announcement

Both low- and high-numbered CR's are announced in NASA announcement journals as appropriate to their security classifications. If unclassified, both types will be abstracted and announced in STAR, "Energy Research Abstracts" (when appropriate), and "Government Reports Announcements and Index." Classified and restricted-distribution reports are neither abstracted nor announced.

Distribution limitations are determined by the NASA Project Manager and approved by the cognizant branch chief.

Microfiche copies of all announced CR's are distributed by NASA Headquarters to NASA centers as well as to many aerospace contractors and others.

Availability

Classified CR's in both the low- and high-numbered subseries are available to qualified requesters from the NASA Scientific and Technical Information Facility, Baltimore/Washington International Airport, Maryland 21240. Unclassified CR's are sold to qualified requestors by NASA and by the National Technical Information Service (NTIS), Springfield, Virginia 22161. Low-numbered CR's are also available for reference in public and some university depository libraries under the Federal Depository Library Program. (The depositories are listed in STAR.)

Contractors wishing to receive information regarding classified documents should request Facility Forms 713 (Registration Form–Technical Publications) and 714 (Certificate of Facility Clearance) from STIF at the address given previously.

Format and Content

The format in which the information in the CR shall be given is presented in the following sections. The information is generally presented in four main subdivisions; namely, the summary, introduction, main text, and conclusions.

This method of presentation has been found effective in the formal NASA authored reports. By being aware of the way in which the information is to be presented, CR authors will be able to plan and work toward the preparation of the report. The following discussion is limited to what the contractor needs to know and is required to perform.

It is generally practical to specify only the format in which the information is to be presented and not what the report content is to be. Each CR, however, must provide information in sufficient detail to enable any prudent and well-informed investigator to repeat the processes outlined in the CR and obtain essentially the same results.

Cover

Covers should be prepared for all CR's. For low-numbered CR's the camera-ready copy should include a mockup of the cover. For high-numbered CR's the cover may be either bond or a heavier quality paper. (See the section **Binding Regulations and Printing Restrictions**. For information on DOE CR covers, see appendix A.) The front cover should include, in addition to the information shown in figure 1, any special markings such as security classification or distribution limitations specified by the NASA Project Manager. NASA requirements for security classification are as directed by the NASA Physical Security Handbook (NHB 1620.3A). No restrictive markings other than security and official distribution markings should be included on NASA CR's. Samples of Export Administration Regulation (EAR), For Early Domestic Dissemination (FEDD), International Traffic in Arms Regulation (ITAR), and Limited Distribution statements as they appear on CR covers are shown in figure 2.

The cover for NASA high-numbered CR's should contain only the information (and if necessary, distribution limitation and security classification markings) shown in figure 3; covers are not required for low-numbered CR's. Black ink only should be used on covers. The contractor's report number, if included, should be placed below the NASA CR number and should be in an equal or smaller type with the same or a lighter font than that used for the NASA CR number. The CR number, contractor's report number, and the title must be printed on the spine, or backbone, of all paperbound or casebound NASA CR's that have spines, or backbones, ¼ inch or more in width.

A great deal of care should be used in selecting the title, since the title may influence the category in which the report is announced and hence the reader audience that ultimately receives distribution. The title should be unclassified, if at all possible, and should indicate the important areas covered by the report. The title of the report does *not* need to be identical with the title of the contract. No illustrations should be included on the cover, such as photographs or artwork that display the contractor's facility, logo, etc.

On the inside of the front cover, special notices may be printed as specified by the NASA Project Manager. These notices pertain to such matters as reproduction limitation, espionage, legal and supersedure information, safety precautions, statements of compliance with special regulations, and disposition instructions; contractor disclaimer clauses should not be included in either low- or high-numbered CR's.

Foreword

A foreword (or preface) may be included in all CR's for acknowledgments of unusual assistance of a technical nature, or of collaboration with another agency. Although many contractor employees, such as computer programmers, illustrators, or typists, contribute substantially to every CR, such services are considered routine to these employees' positions and acknowledgment for their assistance should not be given in the report. Nor should acknowledgments be made to supervisors or technical committees whose comments and advice result from regular work assignments.

Contents Page

A contents page should be included in lengthy CR's to provide both a guide to the report and a key to its organization. A contents page may also be used in short CR's when the report material is subdivided to a depth that justifies its use. The author decides the level of heading subordination that will be included in the contents. However, if one heading of a given level is used, all headings at this same level of subordination

must be given. For example, if one centerhead, such as that at the beginning of this paragraph, is listed, all other such centerheads must also be listed.

Summary

All NASA CR's should include a summary as the first section of the report. The content of the summary should include the objectives and scope of the work, the main information or results obtained, and the principal conclusions reached, if any.

The summary is a condensation of the CR. It contains essentially the same information as the abstract, except in greater detail. The summary should generally be about 300 words long (equivalent to one single-space typed or word-processed page). The content should be written in depth and detail that will provide the general-interest reader with all the most important aspects of the work and, in addition, give the specialist in the field insight into the details that may be found on reading the entire CR. The summary must be independent of the rest of the report. Therefore, references should not be mentioned, nor should equations, tables, or figures contained in the main report be cited. Any symbols used in the summary must be defined there.

All information given in the summary must also be stated explicitly in the main body of the text, rather than being included only in a table or figure. Nothing should be added in the summary that is not included in the main text of the CR. The summary information must also agree with that in the concluding section.

Introduction

All NASA CR's must contain an introduction. The introduction provides a basis for understanding the information to follow and provides the relation between the subject work and previous and current work in the same field or with some program of which the subject work is a part. As much of the following material as is applicable should be included in the introduction:

(1) The background that preceded and led to the subject work
(2) Recognition of similar or related work
(3) The scope of the present work
(4) The relevance of the material reported to the general field
(5) The significance of the material reported
(6) The purpose of the subject effort, precisely defined
(7) The conditions under which the work was done and the procedure used. These should be described in reasonable detail, particularly if unusual conditions or procedures are involved, but should only summarize procedural detail contained in the main text.

The introduction should include information concerning unusual aspects of the CR. For example, such items as a film or video cassette supplement, a supplementary report, an appendix prepared by an author other than the author(s) of the report, or a computer program available from the Computer Software Management and Information Center (COSMIC) should be mentioned in this section. The introduction should *not* include a summary of the CR.

Main Text

The central theme of the CR is developed in the main text. The organization of the CR varies according to the type of subject matter. A vast range of subject material is covered in CR's, and the organization of the main body of each CR must reflect both the general type of work and the specific nature of the contract effort. Some general types of reports and the major subdivisions of the main text that could be used for each are

Experimental report
- (1) Materials or Equipment Tested
- (2) Test Apparatus
- (3) Test Procedures
- (4) Test Results

Analytical report
- (1) Model
- (2) Analytical Procedure
- (3) Results of Analysis

Design report
- (1) Conceptual Design
- (2) Preliminary Design
- (3) Detailed Design
- (4) Manufacturing Design

Hardware development report
- (1) Phase I, Breadboard Model
  - (a) Design
  - (b) Fabrication
  - (c) Test
- (2) Phase II, Experimental Model
  - (a) Design
  - (b) Fabrication
  - (c) Test
- (3) Phase III, Prototype Hardware
  - (a) Design
  - (b) Fabrication
  - (c) Test
- (4) Phase IV, Deliverable Hardware
  - (a) Fabrication
  - (b) Test

Some details to be considered in the development of both experimental and analytical CR's are discussed in the following section.

Descriptive information.—A significant part of the CR is the descriptive information needed for an adequate interpretation of the results. In considering the organization of this part of the report, the author(s) should give particular care to the logical presentation of the results. This may indicate some order other than historical or chronological.

Reports on experimental investigations should include a section on the apparatus used, the models and materials tested, and the instruments used for measurements. The discussion should be amplified by use of pertinent illustrative figures and tables. Information on equipment and test methods should be sufficient to provide the reader with an understanding of the techniques used. Discussion of proprietary materials or processes should be avoided; if these are essential to the duplication of equipment or methods, however, they should be clearly identified by source (parenthetically or in a footnote).

Discrete and infrequent use of trade names to avoid awkward or unsatisfactory use of generic names is permissible in NASA CR's; their use should be avoided if comparisons are being made. If comparisons are being made, the compared materials should be identified by a simple code (a, b, c, etc.) and a parenthetical statement inserted that the code key may be obtained from the NASA Project Manager. Company names may also be used to specify equipment when the results can only be reproduced through use of this specific equipment. But if similar equipment made by another company can be used, the equipment maker should not be named.

If details are available in papers previously published in the open literature, references may be cited for more detailed information. Quantitative data concerning significant dimensions and variables should be given. Test results should be clearly presented with the aid of graphs, tables, and drawings as appropriate. Artwork and other illustrations should be carefully selected and edited to present the information accurately, clearly, and concisely.

Needless repetition of data in illustrations detracts from the reports utility and should be avoided. Illustrations should conform to the standards for figures given in the section Figures. An evaluation of the precision of the equipment, instrumentation, and data, either as percentages or as actual values, should be provided to establish accuracy and confidence level. This information may be presented where the specimens, instrumentation, and data are discussed or, if sufficiently important, in a separate section under a heading such as Precision.

Theoretical or analytical reports may not fit into standard organization patterns. Although one way of subdividing this type of report is given in the section **Main Text**, each such report should be arranged in whatever manner seems most logical.

Since a long theoretical development might be confusing to the reader, the overall pattern of the development may be discussed in the introduction. Each section treating a portion of the development would then begin with a discussion of the development within the section. Theoretical reports generally discuss specific analytical models that are subjected to assumed conditions. Both the model and the assumed conditions should be defined carefully to establish the details of the investigation. Side proofs and incidental material that might disturb the continuity of expression generally should be presented in appendixes to the report. Sometimes results are produced that do not achieve what was desired. It is generally sufficient to mention what was done and why the approach was unsatisfactory without burdening the report with unnecessary detail.

Mathematical presentations.—Research results are often closely associated with the conventions and uses established in mathematics. Short mathematical expressions or equations can be treated as a part of the text when it is convenient to do so. All numbered equations, regardless of length, should be set off on separate lines and centered between margins. Punctuation is not used after serially numbered equations, but introductory statements leading into these equations should conform to correct grammatical usage.

Discussion of Results

All NASA CR's must include a discussion of the results. In short reports the discussion of the results may be combined with other sections. If this is done, the heading should be altered accordingly to, for example, Results and Discussion, and the supporting analysis for each major conclusion should be clearly substantiated to show that it is warranted. Any contradictory theories or results should be explored and differences clearly explained. Comparisons with results of similar work by other investigators should be presented when practical. If the results have an immediate application, this point should be made in the discussion; if suitable, an example to illustrate the method of application may be presented. Since NASA CR's have an interdisciplinary readership, all statements should be clearly understandable to readers who may not be as well acquainted with the subject matter as the author.

Promises of NASA-sponsored research to be published and references to incompleted work in progress should not be included in reference listings, although such a mention (without a cited formal reference) is permissible in the text: "... (Y.E. Ma, 1985, Hughes Aircraft Co., Torrance, CA, personal communication)." If results indicate the possible need for follow-on studies, a simple statement recommending possible areas of investigation should suffice.

Conclusions or Summary of Results

A section normally entitled "Conclusions" or "Summary of Results" should be included in all NASA CR's. This section must be self-contained and must not rely on the main text for interpretation. Undefined symbols must not be used, and equations, tables, figures, appendixes, and references contained elsewhere in the report must not be cited. All results given in the concluding section must also be stated explicitly in the text. All conclusions must be supported by the main text; new material must not be introduced in this section. The concluding section should begin with introductory statements that identify the subject of the report.

The more conclusive investigations close with numbered itemizations of what has been determined. Such itemizations

are best listed under a separate heading Conclusions. If no specific conclusions are drawn, a few remarks might be appropriate under the heading Résumé or Concluding Remarks. This section might give, for example, a broad view of what has been accomplished or of the present status of the problem.

Appendixes

All appendixes to NASA CR's must have titles. Numbering of figures and tables mentioned for the first time in the appendixes normally is a continuation of the numbering in the main text. Equations are usually numbered according to the appendix in which they appear (e.g., (C1), (C2), (C3), etc.); however, they may be numbered as a continuation of the equation numbers in the text.

If many symbols occur in a CR, they must be separately listed, together with their definitions and units, as either the first or last appendix to the CR. This appendix as well as the other appendixes should be listed in the Contents. Further discussion of symbols is given in the section **Symbols**.

References

Publications cited in the CR should be listed under the heading References and placed after the concluding section of the report or, if the CR has appendixes, after the text of the last appendix. Such listed references should be sequentially numbered in order of their mention in the text, tables, and figures. Reference citations are made parenthetically in the text (e.g., (ref. 13)) rather than in footnotes. The name/date style of citation in the text (e.g., (Smith, 1979)) is sometimes preferable because it allows manuscript revision without changing all the reference numbers. The names are listed alphabetically in the reference section. Multiple publications by the same author in the same year are cited by author, year and letter (e.g., Jones, 1979a, 1979b). A document, which has no author listed, is cited in the text by use of an abbreviated title.

When a report is a complete or definitive treatment of a subject, the reference section may be followed by a bibliography listing all the important information sources not listed in the references but pertinent to the investigation. Publications listed in the bibliography are not numbered. The listing may be given in alphabetical or chronological order or may be grouped according to subject matter.

References cited should include only those that the author has actually reviewed. Even if pertinent information in the cited reference actually traces to another source, only the reference actually consulted should be cited. A parenthetical addition to the reference listing should give credit to the original source of the information. Only references that are generally available to requesters may be listed. Papers in preparation or to be published, private communications, and papers for in-house use of specific agencies or field installations do not meet the requirement of availability and must not be listed in the references. These nonformal references should be parenthetically credited where they appear in the text: "... (Y.E. Ma, 1985, Hughes Aircraft Co., Torrance, CA, private communication)." Any NASA reports that are cited must be approved for publication either before or at the same time as the reports in which they are cited. Documents including warnings or notices concerning proprietary rights, even though accessible to certain NASA or contractor employees, are not referenceable unless special clearance is first obtained from the NASA Lewis Chief Counsel.

Many classified publications have unclassified titles, and citation of such papers in unclassified reports is permissible. Authors must use discretion in the use of such references, since these documents can be made available only to qualified recipients. In addition, no classified information from cited classified reports shall be used in an unclassified CR. In essence, the citation of a classified reference in an unclassified CR is allowable as a service to those having access to these documents, but it is otherwise no more than an acknowledgment concerning contributions of other work in a given field. If more extensive use of classified material is essential to the report, the CR itself must bear the same security classification as the reference cited (see the section **Security Requirements**).

The following information should be given for each work in a reference list or bibliography: authors' names, exactly as given on the document referenced (surnames first); the exact title of the work in the language in which it is written (with careful attention to spelling, accent marks, capitalization, and punctuation); the source (including identifying numbers given); and the publication date. Capitalization of foreign titles should follow the conventions in the chapter on foreign language given in the GPO Style Manual. Translation of a foreign title may be added in parentheses. Unpunctuated titles and subtitles should be separated by a dash or a period.

The citation for a book must also give the volume, edition, publisher, place of publication, date (if no date of publication is given, use the copyright date as "© 1979"), and page numbers if specific pages were used. The citation for a periodical must give the name of the periodical and complete source information such as volume, number, month, year, and inclusive pages. The citation of individual Government or industry reports must include the report number (if any), the name of the agency, company or university, and the date.

If a publication is referred to several times in a CR and all the citations are not to the same part of the publication, the page numbers of each part must be given in the place of mention in the CR text. For a book, this page listing in the text makes it unnecessary to cite pages in the reference listing. For a periodical, this page listing will be in addition to the inclusive page numbers that are given in the reference listing or bibliography.

Accuracy in the citation of references is an important responsibility of any author. Carelessness in this respect may

misinform and inconvenience the reader. Because a report often undergoes many revisions during its preparation, the author should make a final review to ensure that each reference citation is correct.

If data from a reference are included in a table or figure, the reference must be cited in the table or figure reproducing these data. An author must obtain prior permission from the copyright holder to reproduce material from a copyrighted work.

Report Documentation Page

Every NASA CR must contain a completed Report Documentation Page (formerly called the COSATI page) as the last left-hand page, facing the back cover. A sample completed Report Documentation Page for an unclassified report is shown in figure 4; a sample of the Report Documentation Page for a classified report is shown in figure 5.

Blocks 1, 4, 5, 7, 8, 9, 10, 11, 12, 13, 15, 16, 17, 18, 19, 20, and 21 must be completed for both low- and high-numbered CR's. Blocks 2, 3, 6, and 14 are left blank. The following numbers in parentheses refer to the block numbers on the form:

(1) Report No.—The NASA CR number assigned by Lewis Research Center (high-numbered CR's) or by NASA Headquarters (low-numbered CR's).

(4) Title and Subtitle—The title of the CR typed in initial capital and lower case letters. If the report is classified, the title is followed by (U) for unclassified, (C) for confidential, or (S) for secret, as applicable. The title should be unclassified if possible.

(5) Report Date—The month and year the report is printed.

(7) Author(s)—The name(s) of the author(s) and the affiliations when one or more differ from that of the organization performing the work. If there is not enough space for the affiliations, that information may be inserted in block 15.

(8) Performing Organization Report No.—The number the contractor has assigned to the CR; if no number is assigned, the word None is inserted in this block, together with the NASA Lewis file number if one has been assigned (E-xxxx).

(9) Performing Organization Name and Address—The name and complete address of the contractor or the university receiving a grant.

(10) Work Unit No.—The NASA Lewis funding number under which the work was done (RTOP). If work was sponsored by another agency, their funding number is listed. If cosponsored, both numbers are listed.

(11) Contract or Grant No.—The Lewis contract or grant number.

(12) Sponsoring Agency Name and Address—If the work is funded by NASA Lewis, this block should read National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio 44135-3191. If funded by another agency, its name and complete address is listed.

(13) Type of Report and Period Covered—The type of report is Contractor Report followed by the kind of report (Final, Interim, Quarterly, Semiannual, Annual, or Topical).

(15) Supplementary Notes—The name, division, and affiliation of the Project Manager. Also included is information such as the presence of microfiche, availability of a film supplement (C-xxx) or of a computer program from COSMIC (LEW-xxxx), an appendix prepared by an author other than the author of the CR, recognition of supplementary funding, and the affiliations of the authors if different from that of the organization performing the work.

(16) Abstract—An abstract of less than 200 words is required. The abstract is primarily used for computerized data banks, for announcement publications, by libraries in their indexing systems, and by many individuals in personal ready-reference automated and desk files for information retrieval. Therefore, the abstract should be unclassified if possible. The abstract must stand alone and should briefly state the main features of the report, including areas investigated, the scope of the work, and the most important results obtained. Any symbol that is used must be defined, references should not be cited, and tables, figures, or equations in the CR should not be referred to. If the report is classified, the abstract is followed by (U) for unclassified, (C) for confidential, or (S) for secret, as applicable.

(17) Key Words (Suggested by Author(s))—Terms or short phrases that identify the principal report subjects for the NASA information system. The key words should be specific and precise so that they can be used for cataloging.

(18) Distribution Statement—The classification and distribution usually listed is Unclassified—Unlimited. The NASA subject category chosen by the author or Project Manager from those subject categories listed in Appendix B. Sample statements for EAR, FEDD, ITAR, and Limited Distribution reports are shown in figure 6. This block is left blank for classified reports.

(19) Security Classif. (of this report)—The security classification Unclassified, Confidential, or Secret, as applicable.

(20) Security Classif. (of this page)—The security classification Unclassified, Confidential, or Secret, as applicable.

(21) No. of Pages—Total number of pages including Report Documentation Page and title page (if there is one).

(22) Price*—Price code, which can be determined from the following price code list:

Price code	Number of pages	Price code	Number of pages
A01	Microfiche		
A02	001–025	A15	326–350
A03	026–050	A16	351–375
A04	051–075	A17	376–400
A05	076–100	A18	401–425
A06	101–125	A19	426–450
A07	126–150	A20	451–475
A08	151–175	A21	476–500
A09	176–200	A22	501–525
A10	201–225	A23	526–550
A11	226–250	A24	551–575
A12	251–275	A25	576–600
A13	276–300	A99	601–up
A14	301–325		

The statement at the bottom of the Report Documentation Page "*For sale by the National Technical Information Service, Springfield, Virginia 22151" should be removed for EAR, FEDD, and ITAR reports. Copies of the blank Report Documentation Page may be obtained from the NASA Project Manager or the NASA Lewis Editorial Branch.

Miscellaneous Style and Quality Requirements

Tables

Contractor Reports (CR's) frequently include tables that present information in a highly concentrated form, particularly information that could not be presented as clearly in any other way. In arranging tabular material, the goal should be clarity and simplicity. Each table must present a complete story in itself without reliance on a text explanation. Numbered tables must have titles and may be inserted in the text near where they are first mentioned or they may be grouped at the back of the report.

Organization.—Tabulated material must be presented in an organized manner (e.g., the material is fitted into neatly ruled columns and rows). Similar data at different conditions are generally presented in columns of the same table with subheadings over the columns to identify the variable conditions. Column headings must include definitions of symbols when symbols are used. Conditions that apply to an entire table are listed in the title of the table or as a headnote to the table, rather than in the individual columns. The numbering sequence for footnotes is by table rows, from left to right in each row and proceeding from the top to the bottom of the table. (See fig. 7.)

Computer-printed output.—The use of computer-printed output should be avoided in a CR whenever possible, since this material invariably includes excessive unscreened data, and the computer-printed output may make the CR unduly bulky. Although this bulk may be reduced by using photographic reduction, care must be taken to ensure that sufficient detail is preserved in this process for legibility. When a computer printout is used, one copy of the complete listings must be transmitted to the NASA Project Manager for technical review. The original copy of a printout to be reproduced in a report must be printed on the unlined side of the computer paper to prevent printing of lines and to present the data as clearly as possible. The bulk of computer printout can be reduced by reproducing it in microfiche form. The NASA Project Manager arranges for microfiche through the Lewis Editorial Branch.

Computer programs should not be listed in the report. They should be made available from COSMIC. The NASA Project Manager will arrange this through the Lewis Technology Utilization Office.

Figures

Layout.—Figures (photographs, drawings, sketches, and graphs) should be numbered with Arabic numerals in the order of their mention, unless the mention is clearly incidental. Figures may be inserted in the text near where they are first mentioned, or they may be grouped at the back of the report if they are so numerous that they interrupt the text. An exception to the requirement for numbering is permissible for small sketches that are part of the text and that follow an introductory statement such as "... as shown in the following sketch:". Such unnumbered sketches should not have a caption and should not be referred to elsewhere in the text. The preferred image area of a CR page is 7⅛ inches wide by 9⅛ inches long on 8½- by 11-inch paper. Within these limits, various sizes, proportions, and arrangements of figures are possible. Two or more figures may be grouped on a page, upright (preferably) or sideways, or the text may be placed above or below the figure, or around a small figure. Oversize figures that require gatefolding when collated in the printed copy should be avoided and should not be used in low-numbered CR's.

Captions and scales.—All figures must have captions (titles). These should describe the major content and not merely repeat column headings or wording on curve coordinates. Also, if a figure has parts (a), (b), (c), etc., it must have corresponding subtitles adjacent to each part, in addition to the main title. Conditions that apply to the entire figure are normally stated as part of the title, or as part of a subtitle if they apply to a part.

Main and auxiliary scale labels must have word definitions. The use of both symbols and units of measurement or of units without symbols (in addition to the word definition) is optional. Auxiliary scales should be added to the bottom or to the left of the figure (outside the grid) if there are four or less scales on each axis. If there are more than four scales on either the left or the bottom of the figure, the additional scales should be added at the right and the top. For ease in interpolation, grid presentations should be developed so that every grid line is a whole number.

Keys should be included if different kinds of symbols or lines are used to identify different data plots. The symbols or lines selected must be consistent throughout a set of figures in the report.

Preparation.—All parts of any one figure should be plotted on the same type of grid (e.g., all inch or all centimeter grid). Each original figure in a classified report must be marked with its individual security classification, including unclassified.

Photographs.—Good quality photographs can clarify the text, but there are times when a simple sketch is more informative. Although a photograph should have no superfluous details in the background, a familiar object or a scale may be included to show comparative dimensions. If a photograph shows a magnified object, the magnification should be indicated, preferably by a scale drawn or included on the photograph or the page. If such a scale cannot be added, the magnification should be given in the figure caption or subtitle. Such a magnified figure should be reproduced without reduction or enlargement to maintain this magnification.

Photographs submitted to NASA Lewis Research Center for reproduction in low-numbered CR's must be continuous tone (*not* halftone) glossy prints, clear in detail, of good tone gradation, and unmarred by marks, scratches, etc. Photographs containing critical detail should be accompanied by additional prints with the important areas encircled for special attention in reproduction. The use of clear acetate overlays for identifiers is optional; direct lettering on the photographs is also acceptable.

Symbols

Standards for letter symbols.—Scientists in special fields have over the years established standard letter and mathematical symbols to provide a common basis of understanding in their communications. In recognition of the existence and value of such standards, NASA has adopted the standards established by the American National Standards Institute (ANSI) for use in NASA publications. Several publications by the Amerian Society of Mechanical Engineers (ASME) list standard symbols for various subjects also. These manuals are especially concerned with concepts associated with aeronautics and space studies and should be consulted first in selecting symbols for NASA reports. When no standards appear to have been established for other concepts used, the letter symbols found in the literature of a particular technical subject are recommended. Single-letter symbols (with subscripts when needed) are preferred over more cumbersome multiletter notations.

Defining symbols.—Although an author in a given scientific field might expect his audience to easily recognize the symbols that he has chosen to represent concepts, symbol usage is not as universal as might be supposed. In addition, reports from one field are often used by workers in other fields. Accordingly, NASA requires the definition of all symbols used in CR's with the exception of chemical symbols. If only a few symbols are used in a CR, each symbol may be defined where it is introduced, either in the text or set off from the text in symbol list form.

It is good practice to include both a symbol list for reference (see the section **Symbols**) and also to define the symbols where they are first introduced. When symbols are defined, either as they are introduced or in a separate section, explanatory information (such as formulas or units) should follow the definitions. Units that are not familiar in a given field should not be abbreviated in a symbol list but rather should be spelled out. A separate symbol list preferably should be alphabetically arranged unless some other order is more logical. If the symbol list includes symbols from both the Latin and Greek alphabets, the Latin alphabet should precede the Greek. If subscript symbols are used, the subscripts should be listed following the main symbols.

Film Supplements

Contractor Reports may include film supplements (available on video cassette) to support the results presented in the report proper. These supplements are particularly useful in demonstrating the behavior of specimens undergoing tests. Because of technical problems involved in the preparing of film supplements, contractor authors contemplating their use should contact the Lewis Technical Information Services Division, through the NASA Project Manager, for consultation and direction. The opening frames in the leader of the supplement should present essentially the same information that appears on the report cover (fig. 1), namely:

(1) Identification of the film as being a supplement to CR-xxxx, the CR title, and the film serial number CRC-xxx (assigned by the NASA Lewis Technical Information Services Division)
(2) Classification (if applicable) of the film
(3) Name of the author of the report and the performing organization
(4) Credit for sponsorship to "National Aeronautics and Space Administration, Lewis Research Center, under Contract or Grant number xxxxx (NASA sponsorship shall be given credit in the leader at least equal to that given to the performing organization.)
(5) Name of the NASA Project Manager and the sponsoring division of the Lewis Research Center

Reports with film supplements have an informative request form bound inside the back cover. (A sample is shown in fig. 8.) Requests are addressed to NASA Lewis Research Center, Chief, Technical Information Services Division (60–1), 21000 Brookpark Road, Cleveland, Ohio 44135.

Errata

Errata are issued to inform recipients of NASA publications of errors of sufficient importance to warrant correction. Minor typographical mistakes will not usually require an errata. An

errata is issued without a cover, but the top of the first page includes the report number, the title, authors, and date of original publication. (See fig. 9.)

An errata should provide the page number and other information that will assist the reader in locating the error. Equations may be identified by their numbers, but text errors should be identified by line. If a page must be replaced, the corrected page should be printed on a separate sheet, with the reverse side left blank, to facilitate insertion in the report. The issue date of the errata is added at the bottom of the page by the Government printer.

If an errata for a classified low-numbered CR does not require classification when separated from the basic report, and if the title is unclassified, the notation "This page is unclassified" should appear at the bottom of each page to avoid the need for registered mail, which is required for transmitting classified documents.

Distribution Lists

Distribution lists should be typed in label form and accompany the camera-ready copy of the report. For low-numbered CR's, the labels are sent to NASA Headquarters with the print order request. For high-numbered CR's, the labels are attached to the printed copies for mailing by the printer or the originating division at Lewis.

Preparation for Delivery

The contractor must package all printed copies or the reproducible copy (see the section **Reproducible Copy**) of a CR securely so that chances of damage in transit are minimized and so that classified reports are not lost or exposed. Quantities stacking more than 4 inches high should be packaged in cartons. Quantities stacking less than 4 inches high should be either packaged in cartons or wrapped in corrugated paper and then enclosed in heavy paper envelopes or outer wrapping. Individual copies mailed in accordance with distribution instructions may be packaged in heavyweight mailing envelopes. Illustrations, photographs, and similar material that cannot be packaged flat should be rolled and shipped in round (shipping tube) containers. Each shipment should include a packing list giving the contract number under which the reports are supplied.

The contractor should send the reproduced reports or the reproducible copy (if required by the contract) to the designated addressee(s) on the distribution list.

Binding Regulations and Printing Requirements

Printing restrictions.—Multiple-copy production normally shall be by the offset duplicating method. Images must be clear, legible, and permanent. Text pages of all CR's produced in 100 copies or more must be duplicated on both sides of the sheet.

Color printing.—Multicolor printing will be permitted only when the use of two or more colors is essential to the technical content of the CR. And then, *prior approval* must be obtained from the Chief of the Lewis Technical Information Services Division through the NASA Project Manager.

Page dimensions and pagination.—The outside dimensions of low-number-series CR pages are nominally fixed at a width of 8½ inches and length of 11 inches. The image area, or area between margins, is a maximum width of 7⅛ inches and a length of 9½ inches including the heading and page number. If the copy provided exceeds the page dimensions, such copy may be reduced to fit these allowable dimensions.

Pagination of front matter (i.e., Foreword or Preface, and Contents page) is in lower case Roman numerals centered at the bottom of the page. The title page in a low-numbered CR is considered to be page i, although no number appears on this page or on page ii, the blank reverse side of page i. Pagination of the report proper is in Arabic numerals with page numbers positioned at the bottom center; the first page of text (starting with the Summary) does not carry a number but is counted as page 1. Right-hand pages are given odd numbers; left-hand pages are given even numbers. If a page is blank, no number is shown, but the blank page is counted in the numbering sequence. The pages of the report are numbered sequentially from beginning to end. Any deviation from numbering the pages in sequence (e.g., numbering the pages of an appendix as A-1, A-2, etc. or putting an odd number on a left-hand page) complicates the printing procedure and requires special attention. Deviations from standard page size (such as gatefolds or separate folded figures to be placed in envelopes) complicate operations so seriously that they must not be included in a low-numbered CR. Tabs also must not be used.

Typing/word processing/typesetting.—CR's should be single spaced with double space separation between paragraphs. To conserve pages, text should be included on pages occupied only partly by figures, when appropriate.

Contractors are required to supply clear, reproducible copy. This copy is then used to prepare negatives for use in photo offset equipment in printing the final copies of low-numbered CR's and may be used for microfiche copying of high-numbered CR's. Satisfactory reproduction requires clean copy typed (with plastic-carbon ribbon), word processed, or typeset. Draft-quality dot-matrix or ink jet printing is unacceptable. The text should be in 12-pitch (approximately 10-point) type. Tables and figures may be done in smaller type (a minimum of 6-point type in the printed report).

Binding.—Plastic bindings, celluloid covers, or die-cut covers should not be used on CR's. High-numbered CR's distributed by the contractor should be bound by (1) saddle stitching, if the report is printed on double-sheet stock, (2) perfect binding, or (3) tape binding. Documents too thick for saddle stitching or convenient handling if perfect or tape bound should be produced in two or more volumes. Prong fasteners, binding screws, plastic combs, and spiral and similar wire fasteners should not be used. Plastic protective sheets must not be used. When hard-cover protection of a document

is needed, the document should be drilled with three round ¼- or ⅜-inch holes, 4¼ inches center-to-center, for insertion into standard three-ring binders. Special stamped, printed, or silk-screened binders should not be used. A single corner staple, or stitch, or a band, should be used to hold the document together until insertion in a binder.

Paper stock.—Text pages should be printed on either of two paper stocks:

(1) Offset book paper, white, substance 50 pounds (basis 25 by 38 per 500 sheets), JCP Specification A60

(2) Chemical wood writing paper, white or colored, substance 20 pounds (basis 17 by 22 per 500 sheets), JCP Specification D10 or D20

Covers other than those of the same paper as the report proper (self covers) should be on either of two paper stocks:

(1) Vellum (or antique finish) cover paper, white or colored, substance 50 pounds (basis 20 by 26 per 500 sheets), JCP Specification L20

(2) Chemical wood index paper, white or colored, substance 110 pounds (basis 25¼ by 30 per 500 sheets), JCP Specification K10.

Reproducible Copy

Special attention should be given to the preparation of all reproducible copy. However, in view of the wide distribution of low-numbered CR's throughout NASA and the scientific community, contractors must take extra care that the reproducible copy submitted for low-numbered CR's is of high quality.

The reproducible copy for a low-numbered CR consists of the master copy of the text, cleanly prepared on white (preferably opaque) paper from which negatives and plates can be made, unscreened continuous tone glossy prints of photographs, and original artwork (or good black and white prints) of a quality suitable for reproduction by offset printing. Reproducible copy should be unbound and should be paginated to establish the proper sequence of the information in the report.

All reproducible copy prepared under the provisions of a NASA contract becomes the sole property of the U.S. Government.

Security Requirements

The security requirements for the review, marking, and safeguarding of classified reports are established by the NASA Physical Security Handbook (NHB 1620.3B). Any questions concerning security classification of a CR should be submitted to the Lewis Security Classification Officer through the NASA Contracting Officer.

Lewis Processing Procedure

Information for Lewis Project Mangers concerning Lewis processing and mandatory distribution approval procedures for NASA CR's is detailed in the Lewis "Research Publications Processing Guide for Scientific and Engineering Authors."

Information from contract work may also be published as a journal article or presented at a technical society meeting or a seminar. For these publications, the contractor must obtain prior approval from the NASA Project Manager for release of technical information relating to the contract. The contractor should forward the request for approval to the Lewis project manager a minimum of 4 weeks in advance of the desired release date to permit sufficient time for review and evaluation.

Appendix A
Requirements for Department of Energy Contractor Reports

Introduction

This appendix applies to all technical work prepared on contractor projects funded by the U.S. Department of Energy (DOE).

DOE publication procedures require that these Contractor Reports (CR's) prepared by their contractors (in this instance, the Lewis Research Center) meet certain DOE format requirements, and that they are numbered in such a way as to permit their identification in the DOE Technical Information System. To meet DOE's requirements as well as those of the NASA Technical Information System, uniform publication procedure standards have been established.

Requirements

The cover (disclaimer on the reverse side), title page, and Report Documentation Page formats are as shown in figures 10 to 13. Covers are printed in No. 347 PMS (green) ink (or its equivalent) on white stock (67-pound vellum).

Cover and Title Page Format

The cover and title page of each CR should contain the information and be arranged as shown in figures 10 and 11. The report title should be brief and should indicate clearly the subject matter covered in the report. The title of the CR need not be the same as that of the contract. If other than a topical or final report, the report type is indicated in a subtitle (e.g., progress report and period covered) in a smaller type size (see fig. 10(b)).

The name(s) of the author(s) appears on the cover and the title page along with the company or grant affiliation. The location of the affiliation is stated only on the title page (see fig. 11). The date (month, year) appears below the location on both pages. The performing organization and contract number are shown under the date (see figs. 10 and 11). The sponsoring agency (DOE) information is given last. On the title page (only) the Interagency Agreement number is given following the sponsoring information (cf. figs. 10 and 11).

Reports are assigned numbers (CR-xxxxx and DOE/NASA/xxxx-xx) under both the NASA and DOE information systems since they are processed and distributed by the technical information systems of both organizations. These numbers appear in the upper left corner on the cover and the upper right corner on the title page. The assignment of both numbers is the responsibility of the Technical Information Services Division (Report Control Office for CR number and Editorial Branch for DOE/NASA/xxxx-xx). If the contractor wishes to assign a company report number, it is printed below the DOE and NASA report numbers as shown in figures 10 and 11. Also, the report numbers and the title are printed on the spine, or backbone, of DOE CR's that are ¼ inch or more in width.

Disclaimer

A disclaimer appears on the inside front cover of all DOE CR's (see fig. 12). The following appears about half way down the disclaimer:

NTIS price codes[1]
Printed copy:
Microfiche copy: A01

To determine the appropriate National Technical Information Service (NTIS) sales price code to insert after "Printed copy:" use the pricing schedule given on p. 8. This same price code must appear in block 22 of the Report Documentation Page (fig. 13).

Report Documentation Page

Completion of a DOE CR Report Documentation Page follows the same format as that of a NASA CR (see pp. 7–8). Figure 13 illustrates specific requirements for DOE CR's. The following numbers in parentheses refer to the block numbers on the form that require information different from that of a NASA CR:

(1) Report No.—The NASA CR number (assigned by Lewis) and the DOE CR number.

(12) Sponsoring Agency Name and Address—The DOE sponsoring *division* is identified in addition to DOE.

(15) Supplementary Notes—The kind of report (Final, Technical, Topical, etc.) is listed. Next is the NASA/DOE Interagency Agreement under which the work was done, followed by the name of the Lewis Project Manager, his division, NASA Lewis Research Center, Cleveland, Ohio 44135-3191.

(17) Key Words (Selected by Author(s))—Authors provide appropriate key words to describe the report contents for the NASA and DOE information systems. The Lewis Technical Information Services Division has copies of TID-7000-R1, "Thesaurus of the DOE Energy Information Data Base." This thesaurus is a highly developed vocabulary for energy-related projects.

(18) Distribution Statement—The NASA and DOE distribution categories are inserted here. A copy of DOE/TIC-4500 (Rev. 74) (DE85007913), "Standard Distribution for Unclassified Scientific and Technical Reports," published by the DOE Technical Information

Center, which describes all categories and specifies the distribution for DOE, is available in Report Control, Lewis Technical Information Services Division.

Report Approval Process

All reports must be submitted to the appropriate DOE Program Manager for approval prior to publication or in accordance with agreements established with the DOE Program Manager. The review copies sent to DOE are to be made from a "clean" copy that incorporates the results of all Lewis review comments. Reproductions of this copy are stamped "DRAFT" and given to the Lewis Project Manager responsible for the work. The Project Manager transmits these review copies to the DOE Program Manager. The number of review copies submitted to the DOE Program Manager should be agreed on by the Lewis Project Manager and his DOE counterpart. Three to five copies should be adequate in most cases.

The Lewis Project Manager should develop an approach with his DOE counterpart to assure the acceptability of reports. For example, agreement on an outline covering key points followed by review of an early draft, redoing until acceptable, before starting the Lewis review cycle.

To avoid a delay in the publication of a CR, the Project Manager should negotiate an agreement with his DOE counterpart limiting the DOE review period. If approval is not received within the specified time, publication should proceed. It is recommended that the period after which publication is automatic should be 10 working days.

Printing

Federal regulations prohibit printing more than 25 000 pages (12 500 sheets of paper printed on both sides) except in government printing offices. For example, a total of no more than 250 copies of a 100-page report is permitted. Therefore, only the number of reports that total 25 000 pages or less are printed by the contractor. The difference between that number and the total needed will be produced by government printing. In such cases, a camera-ready copy of the report is sent to the Lewis Technical Information Services Division for appropriate action.

Distribution

Final and topical reports.—Final and topical reports are given DOE category distribution. If the total number of copies required (DOE category plus special, or supplementary, distribution and Lewis needs) exceeds the 25 000-page limitation, Lewis prints the additional copies. (Mandatory Lewis distribution is given in table II.) The 25 copies for the National Technical Information Service (NTIS) included in the DOE distribution total are withheld and forwarded to the NASA Scientific and Technical Information Facility (STIF) with its 25 copies (see table II). The Facility sends these copies to NTIS. (Reports must not be sent directly to NTIS.)

Progress reports.—Quarterly progress reports are not given DOE or NASA category distribution. The report is announced in STAR unless the Project Manager indicates a limitation on the NASA Document Availability Authorization sent to the Facility by the Lewis Technical Information Services Division.

Supplementary distribution.—When the cognizant Lewis and DOE divisions have a standard supplementary distribution list for a particular DOE category, the DOE Technical Information Center adds that list to its list if requested and makes the distribution. The Lewis Technical Information Services Division will contact the Technical Information Center.

Appendix B
NASA Subject Categories

A AERONAUTICS

Includes aeronautics (general); aerodynamics; air transportation and safety; aircraft communications and navigation; aircraft design, testing and performance; aircraft instrumentation; aircraft propulsion and power; aircraft stability and control; and research and support facilities (air). For related information see also *ASTRONAUTICS.*

01 Aeronautics (General)

02 Aerodynamics

Includes aerodynamics of bodies, combinations, wings, rotors, and control surfaces; and internal flow in ducts and turbomachinery. For related information see also *34 Fluid Mechanics and Heat Transfer.*

03 Air Transportation and Safety

Includes passenger and cargo air transport operations; and aircraft accidents. For related information see also *16 Space Transportation* and *85 Urban Technology and Transportation.*

04 Aircraft Communications and Navigation

Includes digital and voice communication with aircraft; air navigation systems (satellite and ground based); and air traffic control. For related information see also *17 Space Communications, Spacecraft Communcations, Command and Tracking* and *32 Communications and Radar.*

05 Aircraft Design, Testing and Performance

Includes aircraft simulations technology. For related information see also *18 Spacecraft Design, Testing* and *Performance and 39 Structural Mechanics.* For land transportation vehicles see *85 Urban Technology and Transportation.*

06 Aircraft Instrumentation

Includes cockpit and cabin display devices; and flight instruments. For related information see also *19 Spacecraft Instrumentation* and *35 Instrumentation and Photography.*

07 Aircraft Propulsion and Power

Includes prime propulsion systems and systems components, e.g., gas turbine engines and compressors; and on-board auxiliary power plants for aircraft. For related information see also *20 Spacecraft Propulsion and Power, 28 Propellants and Fuels,* and *44 Energy Production and Conversion.*

08 Aircraft Stability and Control

Includes aircraft handling qualities; piloting; flight controls; and autopilots. For related information see also *05 Aircraft Design, Testing and Performance.*

09 Research and Support Facilities (Air)

Includes airports, hangars and runways; aircraft repair and overhaul facilities; wind tunnels; shock tubes and aircraft engine test stands. For related information see also *14 Ground Support Systems and Facilities (Space).*

B ASTRONAUTICS

Includes astronautics (general); astrodynamics; ground support systems and facilities (space); launch vehicles and space vehicles; space transportation; space communications, spacecraft communications, command and tracking; spacecraft design, testing and performance; spacecraft instrumentation; and spacecraft propulsion and power. For related information see also *AERONAUTICS.*

12 Astronautics (General)

For extraterrestrial exploration see *91 Lunar and Planetary Exploration.*

13 Astrodynamics

Includes powered and free-flight trajectories; and orbital and launching dynamics.

14 Ground Support Systems and Facilities (Space)

Includes launch complexes, research and production facilities; ground support equipment, e.g., mobile transporters; and simulators. For related information see also *09 Research and Support Facilities (Air).*

15 Launch Vehicles and Space Vehicles

Includes boosters; operating problems of launch/space vehicle systems; and reusable vehicles. For related information see also *20 Spacecraft Propulsion and Power.*

16 Space Transportation

Includes passenger and cargo space transportation, e.g., shuttle operations; and space rescue techniques. For related information see also *03 Air Transportation and Safety* and *18 Spacecraft Design, Testing and Performance.* For space suits see *54 Man/System Technology and Life Support.*

17 Space Communications, Spacecraft Communications, Command and Tracking

Includes telemetry; space communications networks; astronavigation and guidance; and radio blackout. For related information see also *04 Aircraft Communications* and *Navigation and 32 Communications and Radar.*

18 Spacecraft Design, Testing and Performance

Includes satellites; space platforms; space stations; spacecraft systems and components such as thermal and environmental controls; and attitude controls. For life support systems see *54 Man/System Technology and Life Support.* For related information see also *05 Aircraft Design, Testing and Performance and 39 Structural Mechanics.*

19 Spacecraft Instrumentation

For related information see also *06 Aircraft Instrumentation* and *35 Instrumentation and Photography.*

20 Spacecraft Propulsion and Power

Includes main propulsion systems and components, e.g., rocket engines; and spacecraft auxiliary power sources. For related information see also *07 Aircraft Propulsion and Power, 28 Propellants and Fuels, 44 Energy Production and Conversion,* and *15 Launch Vehicles and Space Vehicles.*

C CHEMISTRY AND MATERIALS

Includes chemistry and materials (general); composite materials; inorganic and physical chemistry; metallic materials; nonmetallic materials; propellants and fuels; and materials processing.

23 Chemistry and Materials (General)

24 Composite Materials

Includes physical, chemical, and mechanical properties of laminates and other composite materials. For ceramic materials see *27 Nonmetallic Materials.*

25 Inorganic and Physical Chemistry

Includes chemical analysis, e.g., chromatography; combustion theory; electrochemistry; and photochemistry. For related information see also *77 Thermodynamics and Statistical Physics.*

26 Metallic Materials

Includes physical, chemical, and mechanical properties of metals, e.g., corrosion; and metallurgy.

27 Nonmetallic Materials

Includes physical, chemical, and mechanical properties of plastic, elastomers, lubricants, polymers, textiles, adhesives, and ceramic materials. For composite materials see *24 Composite Materials.*

28 Propellants and Fuels

Includes rocket propellants, igniters and oxidizers; their storage and handling procedures; and aircraft fuels. For related information see also *07 Aircraft Propulsion and Power, 20 Spacecraft Propulsion and Power,* and *44 Energy Production and Conversion.*

29 Materials Processing in Space and Microgravity

Includes space-based development of products and processes for commercial application. For biological materials see *55 Space Biology.*

D ENGINEERING

Includes engineering (general); communications and radar; electronics and electrical engineering; fluid mechanics and heat transfer; instrumentation and photography; lasers and masers; mechanical engineering; quality assurance and reliability; and structural mechanics. For related information see also *PHYSICS.*

31 Engineering (General)

Includes vacuum technology; control engineering; display engineering and cryogenics; and fire prevention.

32 Communications and Radar

Includes radar; land and global communications; communications theory; and optical communications. For related information see also *04 Aircraft Communications and Navigation* and *17 Space Communications, Spacecraft Communications, Command and Tracking.* For search and rescue see *03 Air Transportation and Safety* and *16 Space Transportation.*

33 Electronics and Electrical Engineering

Includes test equipment and maintainability; components, e.g., tunnel diodes and transistors; microminiaturization; and integrated circuitry. For related information see also *60 Computer Operations and Hardware* and *76 Solid-State Physics.*

34 Fluid Mechanics and Heat Transfer

Includes boundary layers; hydrodynamics; fluidics; mass transfer and ablation cooling. For related information see also *02 Aerodynamics* and *77 Thermodynamics and Statistical Physics.*

35 Instrumentation and Photography

Includes remote sensors; measuring instruments and gages; detectors; cameras and photographic supplies; and holography. For aerial photography see *43 Earth Resources and Remote Sensing.* For related information see also *06 Aircraft Instrumentation and 19 Spacecraft Instrumentation.*

36 Lasers and Masers

Includes parametric amplifiers. For related information see also *76 Solid-State Physics.*

37 Mechanical Engineering

Includes auxiliary systems (nonpower); machine elements and processes; and mechanical equipment.

38 Quality Assurance and Reliability

Includes product sampling procedures and techniques; and quality control.

39 Structural Mechanics

Includes structural element design and weight analysis; fatigue; and thermal stress. For applications see *05 Aircraft Design, Testing and Performance and 18 Spacecraft Design, Testing and Performance.*

E GEOSCIENCES

Includes geosciences (general); earth resources and remote sensing; energy production and conversion; environment pollution; geophysics; meteorology and climatology; and oceanography. For related information see also *SPACE SCIENCES.*

42 Geosciences (General)

43 Earth Resources and Remote Sensing

Includes remote sensing of earth resources by aircraft and spacecraft; photogrammetry; and aerial photography. For instrumentation see *35 Instrumentation and Photography.*

44 Energy Production and Conversion

Includes specific energy conversion systems, e.g., fuel cells; global sources of energy; geophysical conversion; and windpower. For related information see also *07 Aircraft Propulsion and Power, 20 Spacecraft Propulsion and Power,* and *28 Propellants and Fuels.*

45 Environment Pollution

Includes atmospheric, noise, thermal, and water pollution.

46 Geophysics

Includes aeronomy; upper and lower atmosphere studies; ionospheric and magnetospheric physics; and geomagnetism. For space radiation see *93 Space Radiation.*

47 Meteorology and Climatology

Includes weather forecasting and modification.

48 Oceanography

Includes biological, dynamic, and physical oceanography; and marine resources. For related information see also *43 Earth Resources and Remote Sensing.*

F LIFE SCIENCES

Includes life sciences (general); aerospace medicine; behavioral sciences; man/system technology and life support; and space biology.

51 Life Sciences (General)

52 Aerospace Medicine

Includes physiological factors; biological effects of radiation; and effects of weightlessness on man and animals.

53 Behavioral Sciences

Includes psychological factors; individual and group behavior; crew training and evaluation; and psychiatric research.

54 Man/System Technology and Life Support

Includes human engineering; biotechnology; and space suits and protective clothing. For related information see also *16 Space Transportation.*

55 Space Biology

Includes exobiology; planetary biology; and extraterrestrial life.

G MATHEMATICAL AND COMPUTER SCIENCES

Includes mathematical and computer sciences (general); computer operations and hardware; computer programming and software; computer systems; cybernetics; numerical analysis; statistics and probability; systems analysis; and theoretical mathematics.

59 Mathematical and Computer Sciences (General)

60 Computer Operations and Hardware

Includes hardware for computer graphics, firmware, and data processing. For components see *33 Electronics and Electrical Engineering.*

61 Computer Programming and Software

Includes computer programs, routines, algorithms, and specific applications, e.g., CAD/CAM.

62 Computer Systems

Includes computer networks and special application computer systems.

63 Cybernetics

Includes feedback and control theory, artificial intelligence, robotics and expert systems. For related information see also *54 Man/System Technology and Life Support.*

64 Numerical Analysis

Includes iteration, difference equations, and numerical approximation.

65 Statics and Probability

Includes data sampling and smoothing; Monte Carlo method; and stochastic processes.

66 Systems Analysis

Includes mathematical modeling; network analysis; and operations research.

67 Theoretical Mathematics

Includes topology and number theory.

H PHYSICS

Includes physics (general); acoustics; atomic and molecular physics; nuclear and high-energy physics; optics; plasma physics; solid-state physics; and thermodynamics and statistical physics. For related information see also *ENGINEERING.*

70 Physics (General)

For precision time and time interval (PTTI) see *35 Instrumentation and Photography.* For geophysics, astrophysics or solar physics see *46 Geophysics, 90 Astrophysics,* or *92 Solar/Physics.*

71 Acoustics

Includes sound generation, transmission, and attenuation. For noise pollution see *45 Environment Pollution.*

72 Atomic and Molecular Physics

Includes atomic structure, electron properties, and molecular spectra.

73 Nuclear and High-Energy Physics

Includes elementary and nuclear particles; and reactor theory. For space radiation see *93 Space Radiation.*

74 Optics

Includes light phenomena and optical devices. For lasers see *36 Lasers and Masers.*

75 Plasma Physics

Includes magnetohydrodynamics and plasma fusion. For ionospheric plasmas see *46 Geophysics.* For space plasmas see *90 Astrophysics.*

76 Solid-State Physics

Includes superconductivity. For related information see also *33 Electronics and Electrical Engineering* and *36 Lasers and Masers.*

77 Thermodynamics and Statistical Physics

Includes quantum mechanics; theoretical physics; and Bose and Fermi statistics. For related information see also *25 Inorganic and Physical Chemistry* and *34 Fluid Mechanics and Heat Transfer.*

I SOCIAL SCIENCES

Includes social sciences (general); administration and management; documentation and information science; economics and cost analysis; law, political science, and space policy; and urban technology and transportation.

80 Social Sciences (General)

Includes educational matters.

81 Administration and Management

Includes management planning and research.

82 Documentation and Information Science

Includes information management; information storage and retrieval technology; technical writing; graphic arts; and micrography. For computer documentation see *61 Computer Programming and Software.*

83 Economics and Cost Analysis

Includes cost effectiveness studies.

84 Law, Political Science and Space Policy

Includes NASA appropriation hearings; aviation law; space law and policy; international law; international cooperation; and patent policy.

85 Urban Technology and Transportation

Includes applications of space technology to urban problems; technology transfer; technology assessment; and surface and mass transportation. For related information see *03 Air Transportation and Safety, 16 Space Transportation,* and *44 Energy Production and Conversion.*

J SPACE SCIENCES

Includes space sciences (general); astronomy; astrophysics; lunar and planetary exploration; solar physics; and space radiation. For related information see also *GEOSCIENCES.*

88 Space Sciences (General)

89 Astronomy

Includes radio, gamma-ray, and infrared astronomy; and astrometry.

90 Astrophysics

Includes cosmology; celestial mechanics; space plasmas; and interstellar and interplanetary gases and dust. For related information see also *75 Plasma Physics.*

91 Lunar and Planetary Exploration

Includes planetology; and manned and unmanned flights. For spacecraft design or space stations see *18 Spacecraft Design, Testing and Performance.*

92 Solar Physics

Includes solar activity, solar flares, solar radiation and sunspots. For related information see also *93 Space Radiation.*

93 Space Radiation

Includes cosmic radiation; and inner and outer earth's radiation belts. For biological effects of radiation see *52 Aerospace Medicine.* For theory see *73 Nuclear and High-Energy Physics.*

K GENERAL

Includes aeronautical, astronautical, and space science related histories, biographies, and pertinent reports too broad for categorization; histories or broad overviews of NASA programs.

99 General

Bibliography

Elsbree, L.; Altizer, N.G.; and Kelly, P.V.: The Heath Handbook of Composition. 10th ed., D.C. Heath and Co., 1981.

Katzoff, S.: Clarity in Technical Reporting. NASA SP–7010, 1964.

Mechtly, E. A.: The International System of Units: Physical Constants and Conversion Factors, Second Revision. NASA SP–7012, 1973.

Federal Council for Science and Technology: Guidelines to Format Standards for Scientific and Technical Reports Prepared by or for the Federal Government, National Aeronautics and Space Administration Implementation Edition, 1969. (69N34000)

Government Printing and Binding Regulations. Joint Committee on Printing, U.S. GPO, April 1977, Reprinted April 1986 with Addenda.

Letter Symbols for Aeronautical Sciences. Y10.7–1954, ASME, 1986.

Letter Symbols for Rocket Propulsion. ASA Y10.14–1959, ASME, 1960.

Letter Symbols for Heat and Thermodynamics. Y10.4–1982, ASME, 1986.

Letter Symbols for Meteorology. Y10.10–1953 (R1973), ASME, 1986.

NASA Publications Manual. NASA SP–7013, 1974.

NASA Physical Security Handbook, NHB 1620.3B.

NASA Thesaurus. Vols. I and II. NASA SP–7053, 1985.

"Research Publications Processing Guide for Scientific and Engineering Authors, NASA Lewis Research Center, 1986.

Symbols, Units, and Nomenclature in Physics. Phys. Today, vol. 15, no. 6, June 1962, pp. 20–30.

U.S. Government Printing Office Style Manual. Revised ed., March 1984.

TABLE I.—SUMMARY OF INFORMATION ABOUT CR's

Classification	Distribution, number of printed copies[a]				Announced in—	Availability	Reference-ability
	NASA category	Author	Project Manager	NASA STIF			
Low-number subseries							
Unclassified	450 to 600	10	10	25	STAR[b]	(c)	No limitations
Confidential/ Secret	100 to 200	(d)	(d)	25	------	(e)	(f)
High-number subseries							
Unclassified	50 to 150	10	3	25	STAR[b]	(c)	No limitations
Confidential/ Secret	50 to 150	(d)	(d)	25	------	(e)	(f)
DOE high-number subseries							
Unclassified	[g]60 to 600	---	3	50	STAR[b]	(c)	No limitations
Confidential/ Secret	[g]100 to 200	---	---	50	------	(e)	(f)

[a]Also distributed in microfiche form.
[b]If not otherwise limited.
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[e]Confidential/Secret NASA reports are available to qualified requestors with a need to know through NASA Headquarters.
[f]Confidential/Secret reports may be referenced in reports of equal or higher classification and in an unclassified report if the title and material used are unclassified.
[g]Department of Energy (DOE) reports are distributed by DOE to DOE UC categories after printing by NASA Lewis.

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NASA Lewis Library	2	NASA Lewis Research Center Attn: Library (60-3) 21000 Brookpark Road Cleveland, OH 44135
NASA Lewis Technical Information Services Division	[c]1	NASA Lewis Research Center Attn: Report Control Office (60–1) 21000 Brookpark Road Cleveland, OH 44135
NASA Headquarters Technical Information Abstracting and Dissemination Facility (STIF)	25	NASA Scientific and Technical Information Facility Attn: Accessioning Dept. P.O. Box 8757 Balt./Wash. International Airport MD 21240
DOE high-numbered subseries		
NASA Project Manager	[b]3	NASA Lewis Research Center Attn: Name of Manager (Mail Stop) 21000 Brookpark Road Cleveland, OH 44135
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NASA Headquarters Technical Information Abstracting and Dissemination Facility (STIF)	50	NASA Scientific and Technical Information Facility Attn: Accessioning Dept. P.O. Box 8757 Balt./Wash. International Airport MD 21240

[a]Project Manager may add to this minimum distribution (e.g., NASA Headquarters Program Office, NASA Lewis staff).
[b]Unless more are requested.
[c]Recorded then forwarded to Lewis Library.

NASA Contractor Report 3977

Stress Waves in Transversely Isotropic Media

The Homogeneous Problem

Elizabeth R.C. Marques and James H. Williams, Jr.

GRANT NAG3–328
MAY 1986

NASA

Figure 1.—Sample cover for low-numbered Contractor Report.

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(d) Limited Distribution notice.

Figure 2.—Sample notices for covers of export-controlled and restricted-distribution Contractor Reports.

NASA Contractor Report 17535

Influence of Large-Scale Motion on Turbulent Transport for Confined Coaxial Jets

Volume I—Analytical Analysis of the Experimental Data Using Conditional Sampling

David C. Brondum and John C. Bennett
The University of Connecticut
Storrs, Connecticut

January 1986

Prepared for
Lewis Research Center
Under Grant NAG3-350

National Aeronautics and
Space Administration

Figure 3.—Sample cover for high-numbered Contractor Report.

NASA
National Aeronautics and Space Administration

Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
NASA CR-179609		

4. Title and Subtitle	5. Report Date
Regenerative Fuel Cell Study for Satellites in GEO Orbit	July 1987
	6. Performing Organization Code

7. Author(s)	8. Performing Organization Report No.
Alexander Levy, Leslie L. Van Dine, and James K. Stedman	FCR-8347
	10. Work Unit No. 506-41-21

9. Performing Organization Name and Address	11. Contract or Grant No.
International Fuel Cells Corporation 195 Governors Highway P.O. Box 739 South Windsor, Connecticut 06074	NAS3-22234
	13. Type of Report and Period Covered Contractor Report Final

12. Sponsoring Agency Name and Address	14. Sponsoring Agency Code
National Aeronautics and Space Administration Lewis Research Center Cleveland, Ohio 44135-3191	

15. Supplementary Notes

Project Manager, Olga D. Gonzalez-Sanabria, Power Technology Division, NASA Lewis Research Center.

16. Abstract

This paper summarizes the results of a 12-month study to identify high performance regenerative hydrogen-oxygen fuel cell concepts for geosynchronous satellite application. Emphasis was placed on concepts with the potential for high energy density (W-hr/lb) and passive means for water and heat management to maximize system reliability. Both polymer membrane and alkaline electrolyte fuel cells were considered, with emphasis on the alkaline cell because of its high performance, advanced state of development and proven ability to operate in a launch and space environment. Three alkaline system concepts were studied. The first, termed the *integrated* design, utilized a configuration in which the fuel cell and electrolysis cells are alternately stacked inside a pressure vessel. Product water is transferred by diffusion during electrolysis operation and waste heat is conducted through the pressure vessel wall, thus using completely passive means for transfer and control. The second alkaline system, referred to as the *dedicated* design, uses a separate fuel cell and electrolysis stack so that each unit can be optimized in size and weight based on its orbital operating period. The third design was a *dual function* stack configuration, in which each individual cell can operate in both the fuel cell and electrolysis mode, thus eliminating the need for two separate stacks and associated equipment. Results indicate that using near term technology energy densities between 46 and 52 W-hr/lb can be achieved at efficiencies of 55 percent. Using advanced lightweight cell construction which has been achieved in experimental cells, composite tankage material for the reactant gases and the reversible stack concept, system energy densities of 115 W-hr/lb can be projected.

17. Key Words (Suggested by Author(s))	18. Distribution Statement
Hydrogen-oxygen fuel cells Geosynchronous orbit Alkaline fuel cells	Unclassified – Unlimited Subject Category 44

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No of pages	22. Price*
Unclassified	Unclassified	81	A05

Figure 4.—Sample completed unclassified Report Documentation Page for high-numbered Contractor Report.

CLASSIFICATION

NASA
National Aeronautics and Space Administration

Report Documentation Page

1. Report No. NASA CR-	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle		5. Report Date
		6. Performing Organization Code
7. Author(s)		8. Performing Organization Report No. None
		10. Work Unit No.
9. Performing Organization Name and Address		11. Contract or Grant No.
		13. Type of Report and Period Covered Contractor Report Final
12. Sponsoring Agency Name and Address National Aeronautics and Space Administration Lewis Research Center Cleveland, Ohio 44135-3191		14. Sponsoring Agency Code
15. Supplementary Notes		
16. Abstract		
17. Key Words (Suggested by Author(s))	18. Distribution Statement	
19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No of pages / 22. Price*
"NATIONAL SECURITY INFORMATION" Unauthorized Disclosure Subject to Criminal Sanctions.	CLASSIFIED BY: _____ DECLASSIFY ON: _____	
WHEN SEPARATED FROM ENCLOSURES, HANDLE THIS DOCUMENTATION PAGE AS: _____		

CLASSIFICATION

Figure 5.—Sample Report Documentation Page form for a classified Contractor Report.

	18. Distribution Statement This document contains information within the purview of the Export Administration Regulations. It may not be transferred to foreign nationals of proscribed destinations without specific approval. Subject Category		
	20. Security Classif. (of this page) Unclassified	21. No of pages	22. Price*

(a) EAR statement.

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	20. Security Classif. (of this page) Unclassified	21. No of pages	22. Price*

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Figure 6.—Sample distribution statements for use in block 18 of the Report Documentation Page of export-controlled and restricted-distribution Contractor Reports.

TABLE V.—TENSILE PROPERTIES OF EXTRUDED TUNGSTEN COMPARED WITH COMMERCIALLY SINTERED AND SWAGED TUNGSTEN

[Minimum cycle temperature, 1500 K in all cases.]

Billet	Reduction ratio	Extrusion temperature, K	Test temperature, K	Ultimate strength, N/cm^2	Approximate yield strength, N/cm^2	Reduction in area, percent	Total elongation, percent	Type of fracture (a)
Sintered and low-velocity extruded billets								
S1	4.0	1840	800	4 860 000	51 000	74	47	Ductile
Vacuum-arc-cast (ac) and low-velocity extruded billets								
A1	5.5	1840	800	4 820 000	--------	32	10	Brittle
A2	5.5	1840	800	4 760 000	4 310 000	63	27	Ductile
Vacuum-arc-cast (dc, reverse polarity) and low-velocity extruded billets								
A3	5.5[b]	2500	800	4 860 000	4 310 000	62	27	Ductile
A4	5.5[b]	↓	650	5 380 000	4 860 000	24	12	Brittle
A5	8.0	↓	800	5 190 000	4 370 000	68	30	Ductile
A6A	5.5	2500	↓	4 290 000	4 080 000	63	28	Ductile
A7A	8.0	↓	↓	4 450 000	3 890 000	37	24	Ductile
A7A	↓	↓	↓	4 230 000	--------	63	23	Ductile
A7A	↓	↓	↓	4 550 000	3 260 000	58	29	Ductile
Vacuum-sintered and high-velocity extruded billets								
SD1	16	2800	800	2 490 000	--------	2	3	Brittle
SD5	9.5	2800	800	2 830 000	--------	--	--	Brittle
Vacuum-arc-cast (dc, reverse polarity) and high-volocity extruded billets								
AD3	16	2800	800	2 920 000	--------	36	38	Ductile
Sintered and swaged commercial rod stock								
M1	----	----	800	4 760 000	--------	74	29	Ductile
M2	----	----	800	4 760 000	4 589 000	75	29	Ductile
Vacuum-arc-cast (dc, reverse polarity) and high-velocity extruded billet								
A6A	5.5	2500	3200	470 000	--------	99	49	Ductile
Sintered and swaged commercial rod stock								
(c)	----	----	3250	449 000	--------	20	25	Brittle

[a]Brittle fracture, no necking; ductile fracture, specimen necked.
[b]Reduction ratio for dies used on these billets was actually 6, but die wear made this 5.5 for most extrusions.
[c]Average of five tensile tests (ref. 8).

Figure 7.—Sample table with subdivisions, missing and repeated values, headnote, and footnotes.

Motion-picture film supplement CRC–1 is available on loan. Requests will be filled in the order received.

The film (16 mm, 15-1/2 min, B&W, silent but projected at sound speed) shows 25 actual tests of cavitation in water. Five tests with varying degrees of cavitation are shown for each of the five flow rates tested. Sufficient information on the test impeller, test stand, and test conditions are presented to make this supplement self explanatory.

Film supplement CRC–1 is available on request to

National Aeronautics and Space Administration
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Chief, Technical Information Services Division (MS. 60–1)
21000 Brookpark Road
Cleveland, Ohio 44135

Date _____

Please send on loan copy of ( ) Film Supplement to report _____

( ) Technical Film TF– _____ ; ( ) Lewis Film C– _____

in the following format (check one):

( ) 3/4 in. U-Matic tape; ( ) 1/2 in. VHS tape; ( ) 16 mm film

Name of organization _____

Street number _____

City and State _____ Zip code _____

Attn: Mr./Ms. _____

Title _____ Telephone ( ) _____

(a) Front.

Figure 8.—Example of Film Supplement Request (contained on separate page at back of CR).

Place
stamp
here

National Aeronautics and Space Administration
Lewis Research Center
Attn: Chief, Technical Information Services Division (60-1)
21000 Brookpark Road
Cleveland, OH 44135

(b) Back.

Figure 8.—Concluded.

ERRATA

NASA Contractor Report CR–1234

THERMODYNAMIC PROPERTIES OF POTASSIUM TO 2100 K

by John Smith

September 1967

Page 3, paragraph 4, line 2: The unit for $U/\epsilon M$ should be centimeter instead of $J/(hr)(cm^2/cm)(K^4)$

Page 6, equation (5): The quantity T^4 should be T^5.

Page 21, line 6: The equation should read

$$(\Delta H^\circ_{298})_V = (H^\circ_{298})_{monomer} - (H^\circ_{298})_c = (H^\circ_{298})_{monomer}$$

Figure 1, page 56: The ordinate scale values should be .1, .2, .4, .6, .8, 1.0, and 2.0×10^6 instead of 1, 2, 4, 6, 8, 1 and 2.

Pages 58 to 61 and 63: Replace figures 3 to 6 and 8 with the attached figures.

(Issue date—added by printer)

Figure 9.—Sample Errata.

DOE/NASA/0215–1
NASA CR–168222
GTEC 31–4773

Advanced Technology Cogeneration System Conceptual Design Study

Closed Cycle Gas Turbines

E.A. Ted Mock and Howard C. Daudet
Garrett Turbine Engine Company

October 1983

Prepared for
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
Lewis Research Center
Under Contract DEN 3–215

for
U.S. DEPARTMENT OF ENERGY
Fossil Energy
Coal Utilization and Extraction

(a) Cover with subtitle.

Figure 10.—Sample cover for Department of Energy Contractor Report.

DOE/NASA/0290–1
NASA CR–174732

Gas Cooled Fuel Cell Systems Technology Development

Final Report for the First Logical Unit of Work Contract Period: May 1982—May 1983

J.M. Feret
Westinghouse Electric Corporation

August 1983

Prepared for
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
Lewis Research Center
Under Contract DEN 3–290

for
U.S. DEPARTMENT OF ENERGY
Morgantown Energy Technology Center

(b) Cover of progress report showing period covered.

Figure 10.—Concluded.

DOE/NASA/0341-1
NASA CR-174991
AV-FR-85/802

Development and Testing of Tip Devices for Horizontal Axis Wind Turbines

G.W. Gyatt and P.B.S. Lissaman
AeroVironment Inc.
Monrovia, California 91016-3424

May 1985

Prepared for
National Aeronautics and Space Administration
Lewis Research Center
Cleveland, Ohio 44135
Under Contract DEN 3-341

for
U.S. DEPARTMENT OF ENERGY
Conservation and Renewable Energy
Wind Energy Technology Division
Washington, D.C. 20545
Under Interagency Agreement DE-AI01-76ET20320

Figure 11.—Sample title page for Department of Energy Contractor Report.

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[1]Codes are used for pricing all publications. The code is determined by the number of pages in the publication. Information pertaining to the pricing codes can be found in the current issues of the following publications, which are generally available in most libraries: *Energy Research Abstracts (ERA); Government Reports Announcements* and Index *(GRA* and I); *Scientific and Technical Abstract Reports (STAR)*; and publication, NTIS–PR–360 available from NTIS at the above address.

Figure 12.—Department of Energy disclaimer.

NASA
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Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
NASA CR-352301 DOE/NASA/0008-3		

4. Title and Subtitle	5. Report Date
Ceramic Components for Heavy Duty Gas Turbines	February 1986
	6. Performing Organization Code
7. Author(s)	8. Performing Organization Report No.
John W. Caswell	EDR 1110
	10. Work Unit No.
9. Performing Organization Name and Address Detroit Diesel Allison Division General Motors Corporation Post Office Box 894 Indianapolis, Indiana 46206	11. Contract or Grant No. DEN 3-8
	13. Type of Report and Period Covered Contractor Report Final
12. Sponsoring Agency Name and Address U.S. Department of Energy Office of Vehicle and Engine R&D Washington, D.C. 20545	14. Sponsoring Agency Code

15. Supplementary Notes

Prepared under Interagency Agreement DE-AI01-77CS51044. Project Manager, William E. Goette, Transportation Propulsion Division, NASA Lewis Research Center, Cleveland, Ohio 44135.

16. Abstract

A program plan was generated to demonstrate a fuel economy of 213 mg/W•h (0.35 lb/hp-hr) brake specific fuel consumption by 1981 through use of ceramic materials, with conformance to current and projected Federal noise and emission standards, and to demonstrate a commercially viable engine. Results show that increased turbine inlet and regenerator inlet temperatures, through the use of ceramic materials, contribute the greatest amount to achieving fuel economy goals. Further, improved component efficiencies (for the compressor, gasifier turbine, power turbine, and regenerator disks show significant additional gains in fuel economy. Fuel saved in a 500,000-mile engine life, risk levels involved in development, and engine-related life cycle costs for fleets (100 units) of trucks and buses were used as criteria to select work goals for the planned program.

17. Key Words (Suggested by Author(s))	18. Distribution Statement
Heavy duty gas turbine engine; Fuel economy; Life cycle costs; Ceramic components; Component efficiencies	Unclassified – Unlimited Subject Category 85 DOE Category UC-96

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No of pages	22. Price*
Unclassified	Unclassified	155	A03

Figure 13.—Sample completed Report Documentation Page for Department of Energy Contractor Report.

NASA
National Aeronautics and Space Administration

Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
NASA TM-100270		

4. Title and Subtitle	5. Report Date
Technical Writing Standards for Contractor Reports	December 1987
	6. Performing Organization Code
7. Author(s)	8. Performing Organization Report No.
	E-3906
	10. Work Unit No.
	None
9. Performing Organization Name and Address	11. Contract or Grant No.
National Aeronautics and Space Administration Lewis Research Center Cleveland, Ohio 44135-3191	
	13. Type of Report and Period Covered
	Technical Memorandum
12. Sponsoring Agency Name and Address	14. Sponsoring Agency Code
National Aeronautics and Space Administration Washington, D.C. 20546-0001	

15. Supplementary Notes

Prepared by Technical Information Services Division.

16. Abstract

This guide is an update of NASA Lewis Handbook 2230.1. It contains publication standards for use in all contractor and grantee reports in the formal NASA CR (Contractor Reports) series.

17. Key Words (Suggested by Author(s))	18. Distribution Statement
Contractor Report Grant Publication standards	Unclassified – Unlimited Subject Category 99

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No of pages	22. Price*
Unclassified	Unclassified	36	A03

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B-0002
December 1987